DOCUMENT RESUME

ED 041 728 SE 008 120

AUTHOR Kurek, Dolores B.; Buell, Robert R.
TITLE A Comparison of Teaching Techniques in Secondary School Chemistry.
INSTITUTION Toledo Univ., Ohio.
PUB DATE Mar 70
NOTE 7p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (43rd, Minneapolis, Minne., March 5-8, 1970)

EDRS PRICE EDRS Price MF-$0.25 HC-$0.45
DESCRIPTORS *Academic Achievement, *Chemistry, Effective Teaching, Evaluation, *Instruction, *Secondary School Science, Sociometric Techniques, Teacher Behavior

ABSTRACT

This report concerns a seven-year longitudinal study of one teacher using a variety of teaching techniques to determine (1) the constancy of a teacher's final grade with regard to a number of independent variables, assessed over such a period, and (2) the effect upon achievement in secondary school chemistry of these independent variables. Subjects were 382 girls who took chemistry at a private academy from 1961-62 through 1967-68. Two control groups were compared with 15 experimental groups for the study of two areas: pedagogical and sociological strategies for teaching high school chemistry. The results of the study indicated that (1) the I.Q. score appeared to be the best estimate of chemistry achievement, (2) the second most effective factor was laboratory procedure, (3) the third most important factor was sociometric seating. Insignificant factors were class size, class duration, negative teaching behaviors, and text used. Four data analysis tables are included in this report. (LC)

National Association for Research in Science Teaching. Minneapolis 1970

A COMPARISION OF TEACHING TECHNIQUES IN SECONDARY SCHOOL CHEMISTRY

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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Dolores B. Kurek
St. Ursula Academy
Toledo, O. 43606
and
Robert R. Buell
The University of Toledo
43606

ED041728

This report concerns a seven-year longitudinal study of one teacher using a variety of teaching techniques and instructional strategies to determine (i) the constancy of a teacher's final grade with regard to a number of independent variables, assessed over such a period, and (ii) the effect upon achievement in secondary school chemistry of these independent variables. Preliminary analysis was by CANOVA with "t" test evaluation of the results, followed by multiple regression analysis using the Biomedical BMD 02R (University of California, Berkeley) program at the University of Washington. This report is concerned only with the second statistical test.

The sample was all those girls (N = 382) who took chemistry at a private academy from 1961-2 through 1967-8, under the junior writer, with the exception of one class of 25, originally designated as a control group, but found to be (on preliminary assessment by IQ and pre-achievement test) significantly different from the other controls and the experimental samples, so it was rejected. All other samples were found on criteria examinations (see Table II) to have no significant differences at the beginning of each year. The treatments and independent variables are shown in Table I chronologically. The Ss ranged in age from 16 to 18, and in class rank from junior to senior; eighteen subgroups were formed. Two control groups were compared with fifteen experimental groups for the study of two well-

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defined areas: pedagogical and sociological strategies for teaching high school chemistry.

The questions which were raised in this investigation concerned the effective teaching and learning of chemistry with variations in (a) class size, (b) class duration, (c) laboratory, lecture and miscellaneous teaching methods, (d) classroom behavior of the teacher (positive and negative teaching behaviors), (e) sociometric seating and working assignments, and (e) instructional materials. Other variables were IQ, pre-achievement test, post-achievement test, and teacher's final grade.

Formal statistical questions were concerned with the correlations between two dependent variables (post-test achievement scores and the teacher's final-grade estimate of achievement) and ten independent variables, some of which were tested more than once. (See Table I for chronological arrangement of factors). Also considered was the correlation (between the two dependent variables) with represented the extent of uniformity of a teacher's grade practices over seven years as contrasted with achievement-test performance by her students.

Essentially, two statistical techniques were employed: analysis of covariance (not reported here), and analysis of multiple regression data by computer. The project consisted of pretesting the students, applying the independent variables in various class organizational patterns in the subgroups, and then comparing the results obtained from a post-test of achievement and the teacher-assigned final course grade. Student surveys of negative teaching behaviors were administered to determine their effects upon learning. Sociograms were employed (for first, second, third choice friends) to assign seating and working space.

Findings

1) Class size, by multiple regression analysis, was not highly significant between the extremes of 8 and 57.

2) Class duration (in minutes, from 5 hours to 6.75 hours per week) had no effect on student achievement.

3) More powerful variables affecting achievement were found to be (in decreasing order) intelligence quotient, laboratory teaching methods, and seating by sociometric means.

4) Learning of high school chemistry (both lecture and laboratory) was more efficacious when students were seated so that they could work with their pre-selected peers, as shown by sociograms.

5) Exhibition of negative teaching behaviors did not significantly affect learning.

6) Physical devices and materials were not related in any large degree to learning.

7) The two dependent variables were both highly correlated with laboratory teaching procedures, sociometry and intelligence quotient; and were also highly correlated with each other over the seven-year span.

8) From the standpoint of methodology, the multiple regression by computer revealed more relationships than the regression equations tested by "Student's t" test.

Conclusions.

The I.Q. score would appear, on the basis of both examination procedures, to be the best estimate of chemistry achievement as adjudged both by teacher-assigned grade and achievement-test; the multiple regression of post-test scores versus all independent variables shows this strikingly, and we wonder if this is because most of the sampling

of achievement was at the "knowledge-application" (Bloom's lowest) level.

The second most effective factor is the laboratory procedure; those practices which aim at student responsibility for investigation and reporting (as opposed to teacher-directed or manual-directed) are crucial in achievement.

The third most important factor in chemistry achievement is sociometric seating, i.e., giving the peer group a choice of work partners in all the course activities.

Miscellaneous teaching factors occupy the forth position, after which we find (in descending order) lecture based on student discussion and effect of negative teaching behavior--but these are not highly significant.

Insignificant factors were class size; class duration; text used. We conclude that self-chosen groups tend to ignore total class size, that five hours per week of meaningful work accomplishes as much as six-and-three-quarters hours, and that text (in either demonstration or inquiry laboratory) is not nearly as important as teacher positive or negative behavior--which means that students are still highly motivated to "please Teacher".

Significant interactions occur on post-test achievement with (i) two hours additional student-directed laboratory, (ii) student discussion with lecture over lecture-demonstration, (iii) the class of 25 achieving more than one of 57, (iv) sociometric seating.

TABLE I

INSTRUCTIONAL AND LEARNING VARIABLES IN THE STUDY

Year	N.	VARIABLES
CONTROLS		
1962/3	25	Control A-1. 3 lecture 4 lab periods/week, all 45 min.; theory before lab; Text 1, Achievement Test 1.
1966/7	25	Control A-2. 3 lecture, 2 lab periods/week, all 60 min.; theory before lab; Text 2, Achievement Test 2.
INDEPENDENT VARIABLES		
1961/2	11	B-1) Class size; double vs single lab period
	26	B-2) since all 3 had 3 lecture, 6 lab periods
	25	B-3) all 45 min. Theory before lab.
		Class size; no lab work-all teacher demonstrations
1963/4	25	C-1) 7 lecture-demonstration periods (45 min.) per
	57	C-2) week with students filling in manual as they watched; sociometric grouping; class size.
1964/5		No teacher-controlled lecture-demonstration
	8	D-1) 7 laboratory-discussion periods (45 min. each)
	22	D-2) with at least 5 for student experiments and
	21	D-3) 2 for student-controlled lecture; D-2 and -3
		Textbook and achievement test change; sociometric groups; class size.
1965/6	12	E-1) All groups had Teacher A for 1 mo.; then E-1, -2
	28	E-2) had B, and E-3 had C for 4 mo.; then all had A
	25	E-3) for balance of $9\frac{1}{2}$ mo. year; sociometric seating of E-2, -3; Negative teaching behaviors; period length; no lab manual, but individual write-ups alternated with teacher-made manual-sheets.
1966/7	18	F-1) 3 lecture-demonstration and 4 lab periods/week
		F-2) (60 min.); no lab manual; the F-2 had only 2 lab periods (60 mon.)
		Class size; lab write-up; sociometric seating
1967/8	9	G-1) Unique physical disposition of class.
	18	G-2) Both classes had 3 lecture periods, 2 lab periods per week (60 min.); G-2 seated sociometrically.

TABLE II
INSTRUMENTS USED IN THE CHEMISTRY STUDY

IQ	California Test of Mental Maturity (throughout)
Chemistry Achievement	Groups A-1, B, C, D,: ACS-NSTA Cooperative Exam. (Form 1961) Groups A-2, E, F, G,: Anderson-Fisk Chemistry Test. (Form E, 1966)
Check list of Pupil Perception of Teaching Behaviors	Teacher-made instrument based on Ryan's modes
Sociometric Chart	Sociogram based on 1, 2, 3 choices of "best friends in class."

TABLE III

COMPUTER DATA: Teacher-Assigned Final Grade versus
All Independent Variables

Variable Entered	Code	Multiple R	Standard Error of Estimate	F Value
I.Q.	2	0.7233	1.6461	17.5524
Lab	6	0.8017	1.4716	5.0206
Social	11	0.8619	1.2923	5.4494
Time	5	0.8724	1.2927	0.9923
Lecture	7	0.8814	1.3000	0.8541
Miscel.	8	0.8882	1.3211	0.6196
PreTest	3	0.8909	1.3697	0.2327
Size	4	0.8956	1.4137	0.3881
Negat.At.	10	0.8959	1.4974	0.0222
Nat'l	9	———	———	0.0000

TABLE IV

Computer Data: Post-Test Achievement Scores Versus
All Independent Variables

Variable Entered	Code No.	Multiple R	Standard Error of Estimate	Value
I.Q.	2	0.6423	10.1084	11,2343
Lab	6	0.7024	9.6951	2.3931
Sociol	11	0.8553	7,3040	12.4288
Misc.	8	0.8760	7.0553	2.0043
Lecture	7	0.8893	6.9632	1.3461
Neg.Tchg	10	0.9211	6.1908	4.1811
PreTest	3	0.9232	6.4127	0.2519
Size	4	0.9269	6.5990	0.4434
Time	5	0.9280	6.9486	0.1170
Mat'l	9	———	———	0.0000